

**N91 - 18193**

**ACOUSTO-ULTRASONIC NONDESTRUCTIVE  
EVALUATION OF MATERIALS USING  
LASER BEAM GENERATION AND DETECTION**

Robert D. Huber and Robert E. Green Jr.  
Center for Nondestructive Evaluation  
The Johns Hopkins University  
and  
Alex Vary and Harold Kautz  
NASA/Lewis Research Center

This work has been supported in part by  
NASA/Lewis Research Center  
Through NASA Grant #NAG3-728

## **RESEARCH OBJECTIVE**

**TO INVESTIGATE THE POSSIBILITY OF USING LASER  
GENERATION AND DETECTION OF ULTRASOUND TO  
REPLACE PIEZOELECTRIC TRANSDUCERS FOR THE  
ACOUSTO-ULTRASONIC TECHNIQUE.**

## **ADVANTAGES OF LASER ACOUSTO-ULTRASONICS**

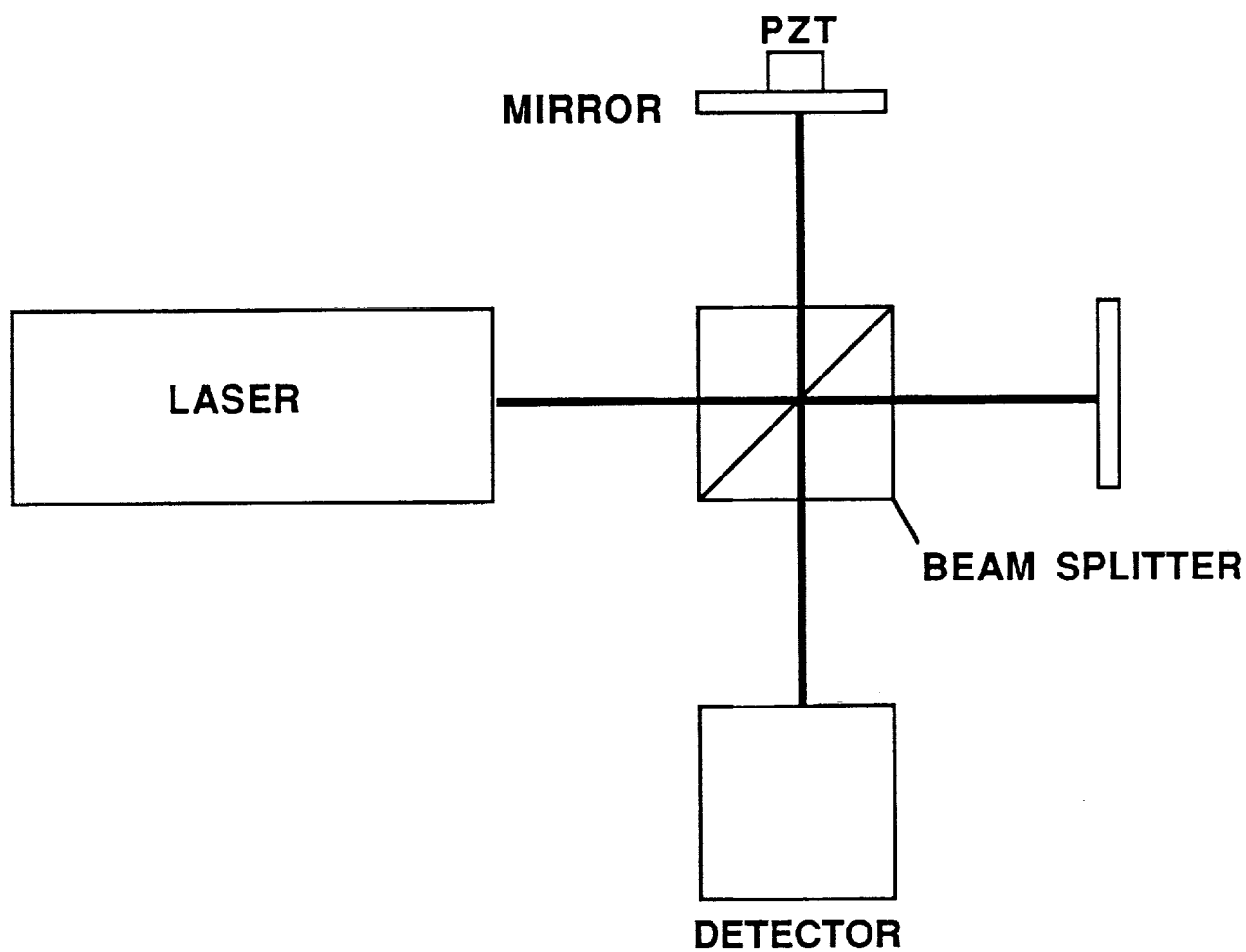
- **NON-CONTACT TESTING**
- **PIEZOELECTRIC TRANSDUCER COUPLING PROBLEMS ELIMINATED**
  - CONTACT PRESSURE**
  - COUPLANT**
  - TESTING HOT SURFACES OR IN HOSTILE ENVIRONMENTS**
- **RESONANCE OF TRANSDUCERS ELIMINATED**
- **POINT DETECTION**
- **NARROW AND WIDE BAND DETECTION**
- **DETECTION NEAR MATERIAL EDGES**

## **DISADVANTAGES OF LASER DETECTION**

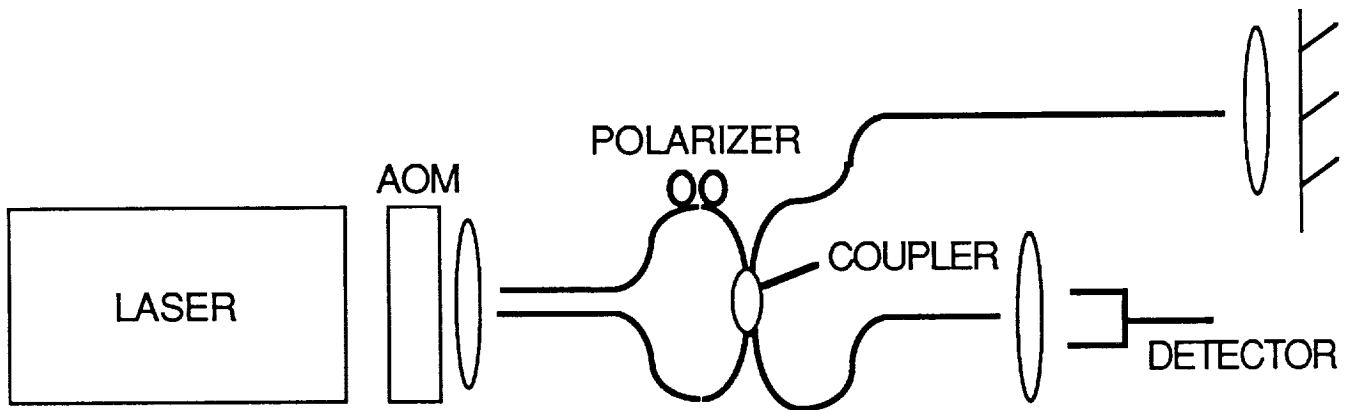
- **SURFACE MUST BE REFLECTIVE**
- **NOT AS SENSITIVE AS PIEZOELECTRIC TRANSDUCERS**
- **OPTICAL SYSTEMS ARE OFTEN MORE EXPENSIVE**

## **TYPES OF INTERFEROMETERS USED**

- PATH STABILIZED BULK SYSTEM**
- HETERODYNE FIBER OPTIC SYSTEM**



## **PATH STABILIZED INTERFEROMETER**



## HETERODYNE FIBER OPTIC INTERFEROMETER

# INTERFEROMETER

## SENSITIVITY CONSIDERATIONS

$$\text{SNR} \propto \left[ \frac{R P_o \eta}{h \nu \Delta \nu} \right]^{1/2} \frac{\delta}{\lambda}$$

**h : PLANCK'S CONSTANT**

**$\lambda$  : OPTICAL WAVELENGTH**

**$\eta$  : DETECTOR QUANTUM EFFICIENCY**

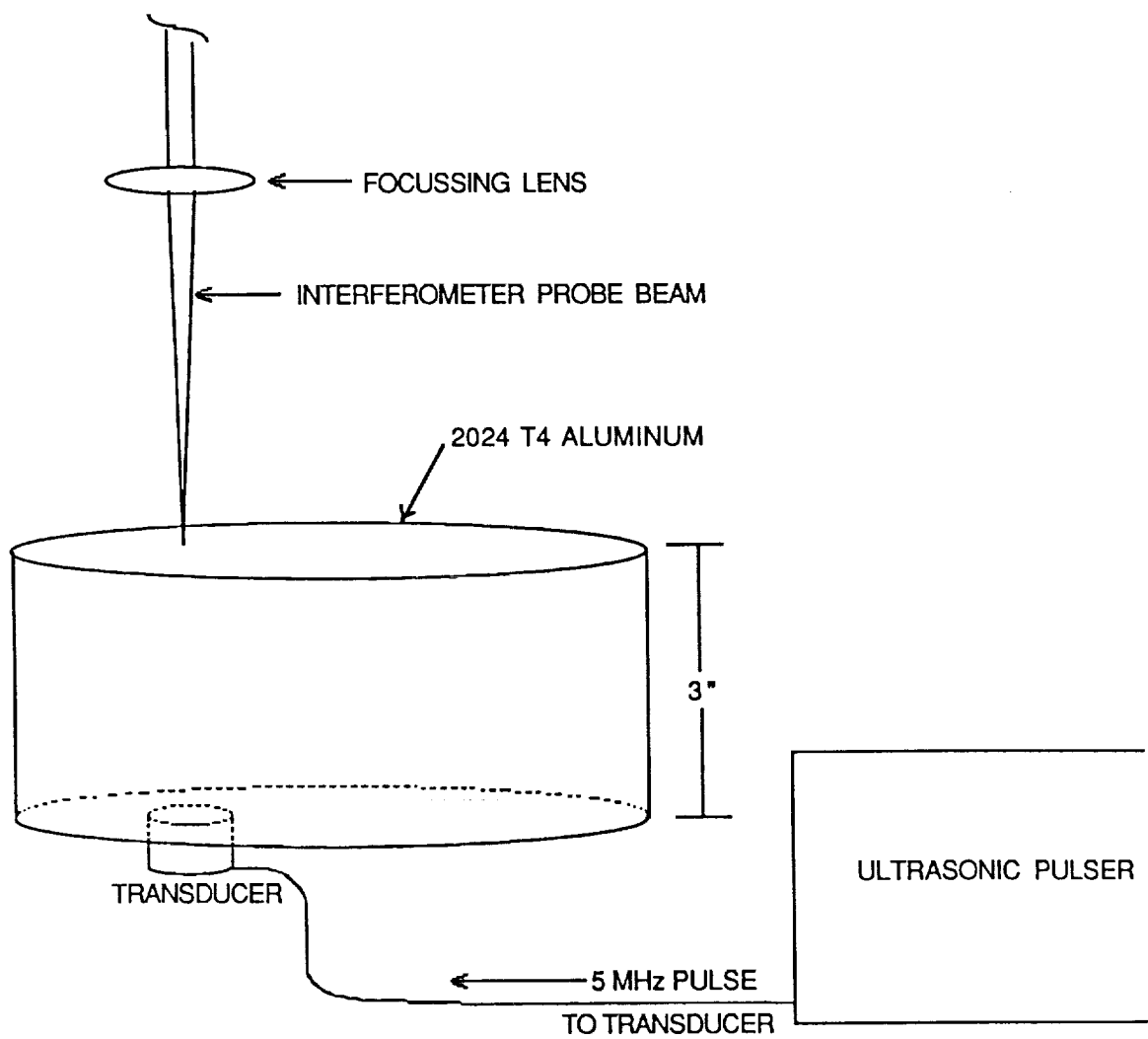
**$\delta$  : SIGNAL AMPLITUDE**

**$\Delta \nu$  : DETECTION BANDWIDTH**

**R : SAMPLE REFLECTIVITY**

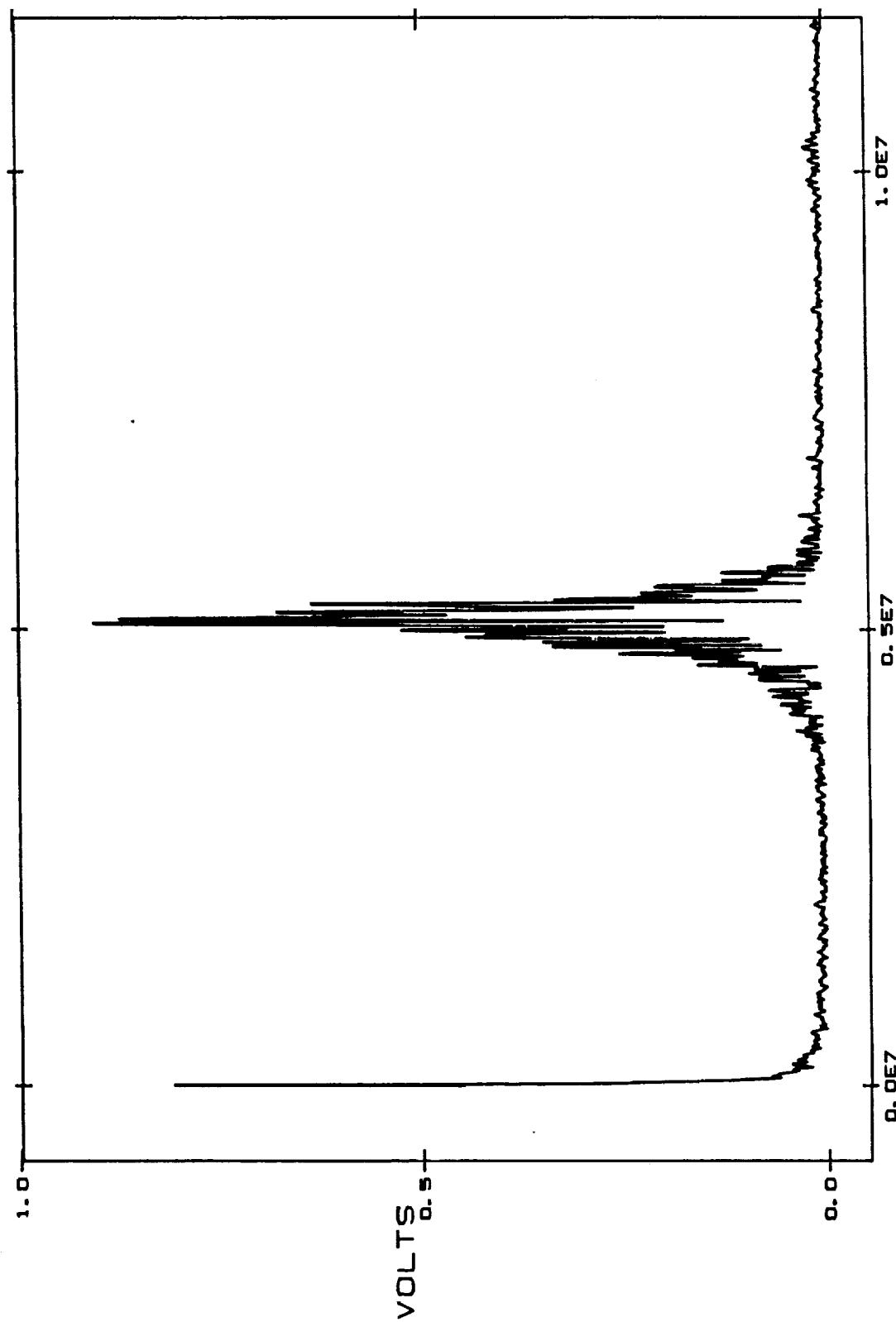
**$P_o$  : LASER POWER**







MAG. A1



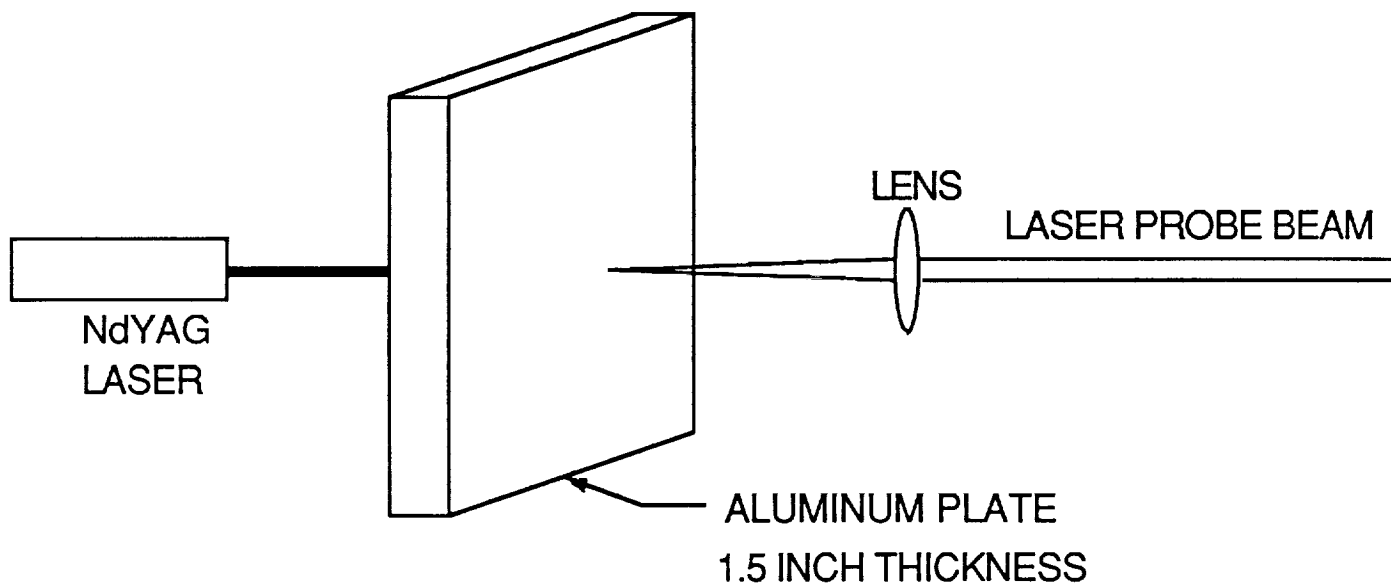
# **LASER GENERATION OF ULTRASOUND**

## **KIGRE Nd YAG PULSED LASER**

**17 mJ PER PULSE**

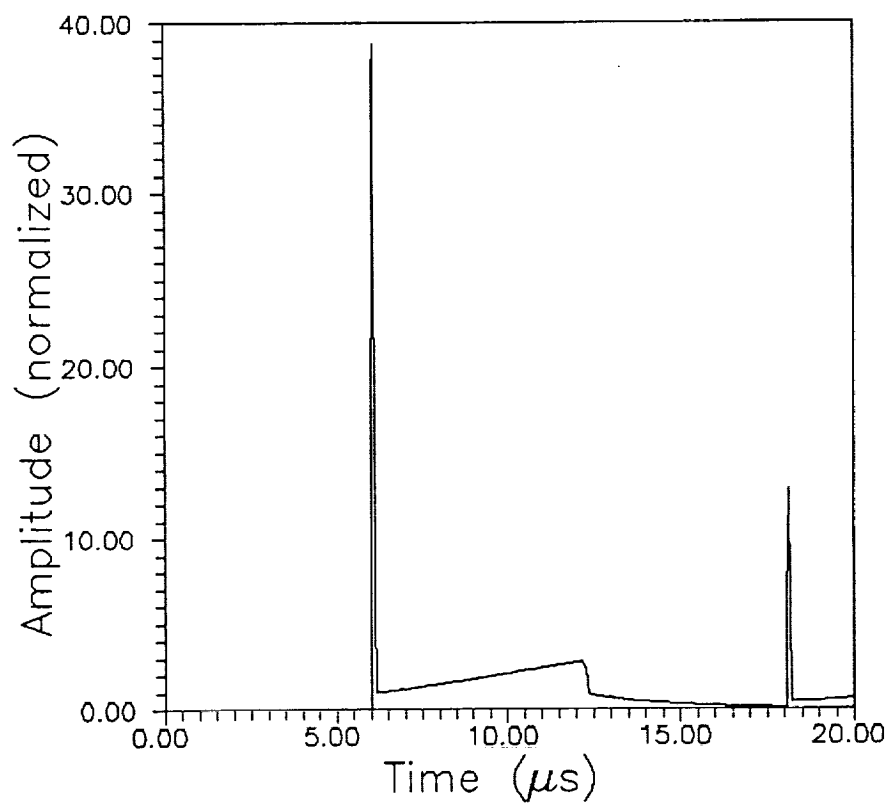
**4 ns PULSE LENGTH**

**3 mm BEAM DIAMETER**

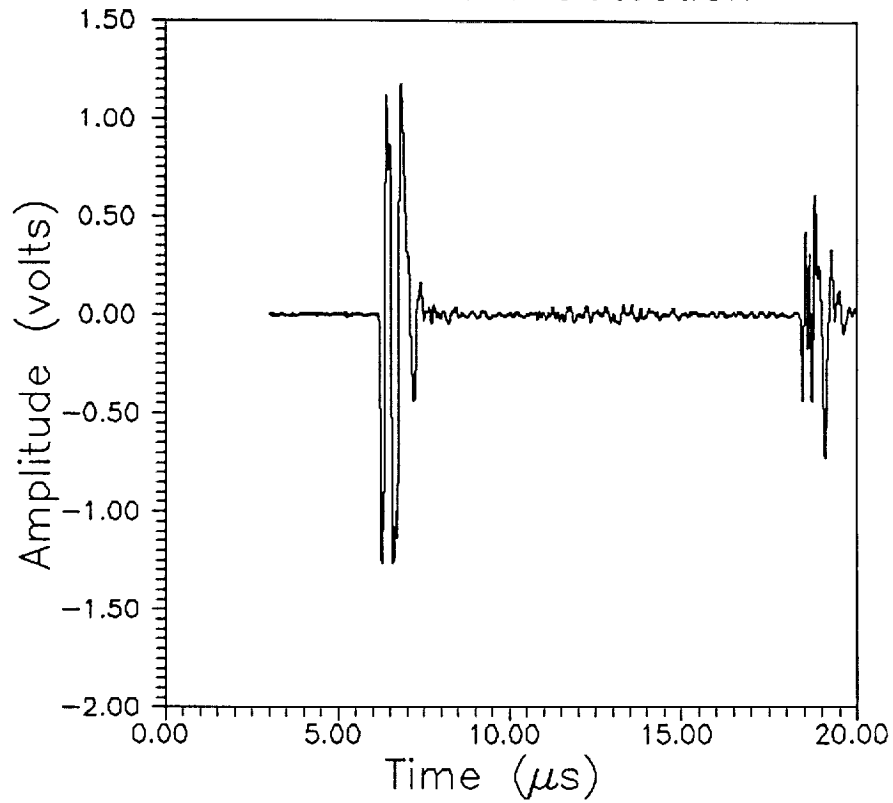


NON-CONTACT GENERATION AND DETECTION OF  
ULTRASOUND IN AN ALUMINUM BLOCK

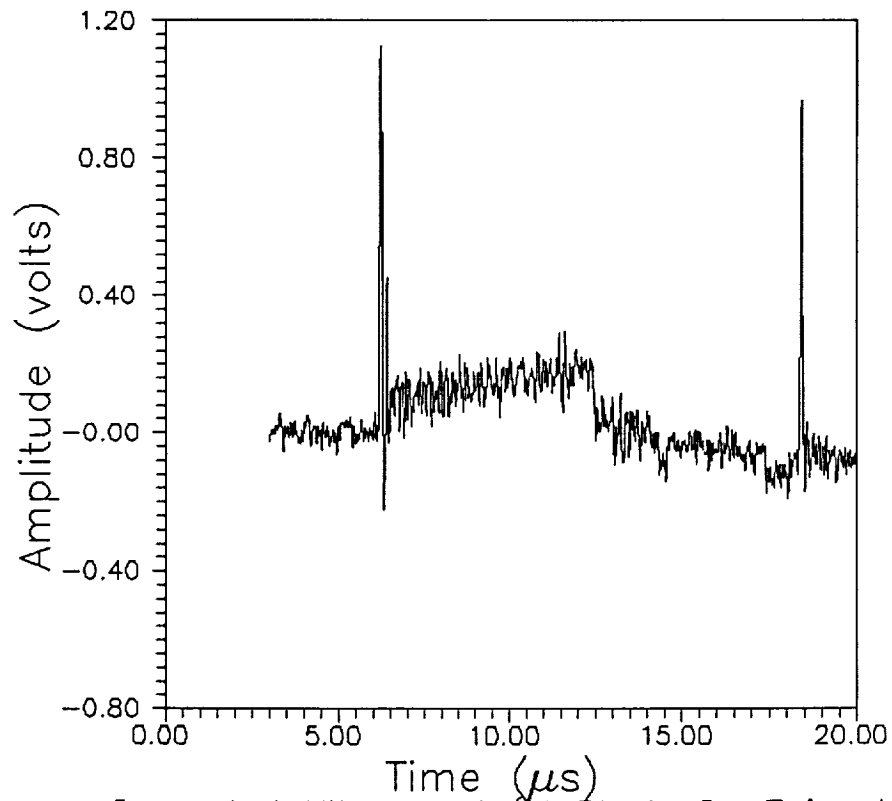
Theoretical Surface Displacement For Laser  
Generated Ultrasound In A 1.5 in Al Block  
On Epicenter



### Piezoelectric Detection

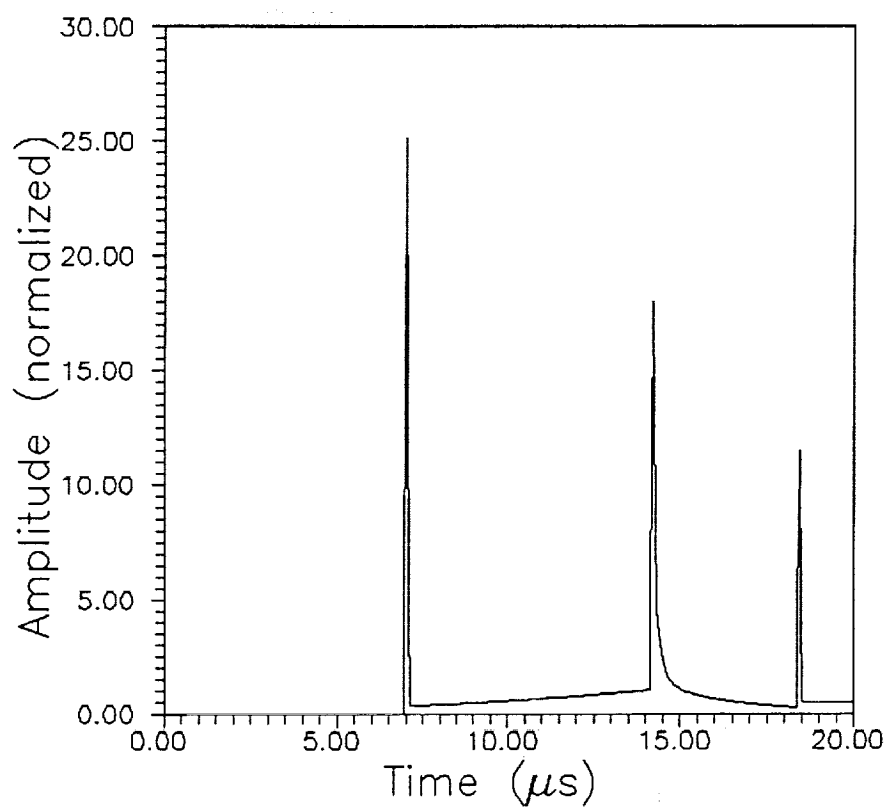


### Interferometric Detection



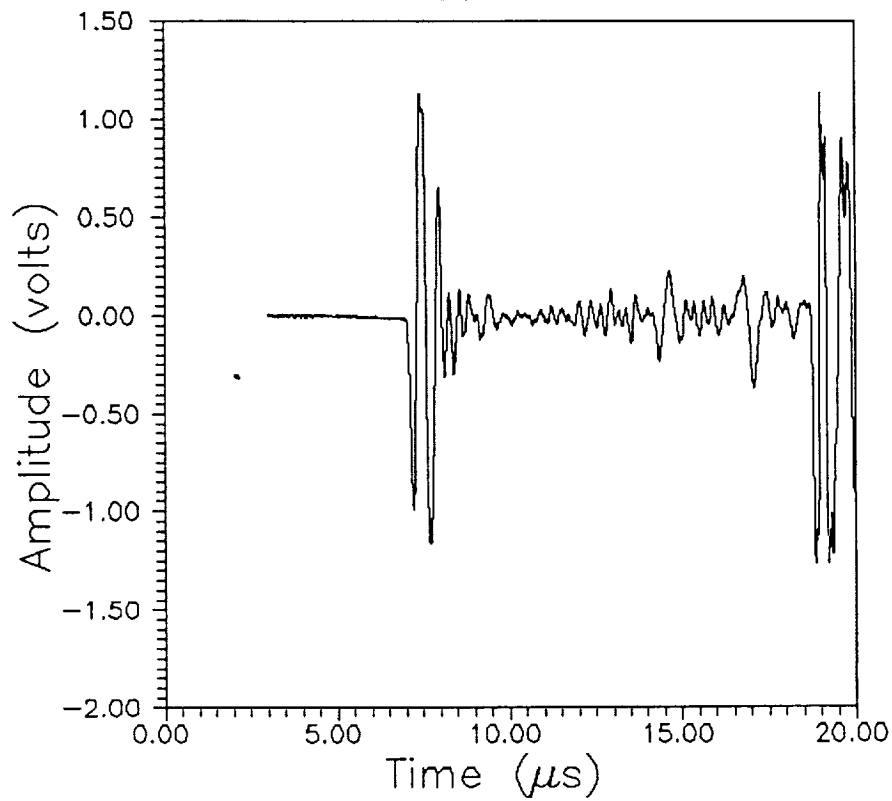
Laser Generated Ultrasound (Al Block-On Epicenter)

Theoretical Surface Displacement For Laser  
Generated Ultrasound In A 1.5 in Al Block  
7/8 in Off Epicenter

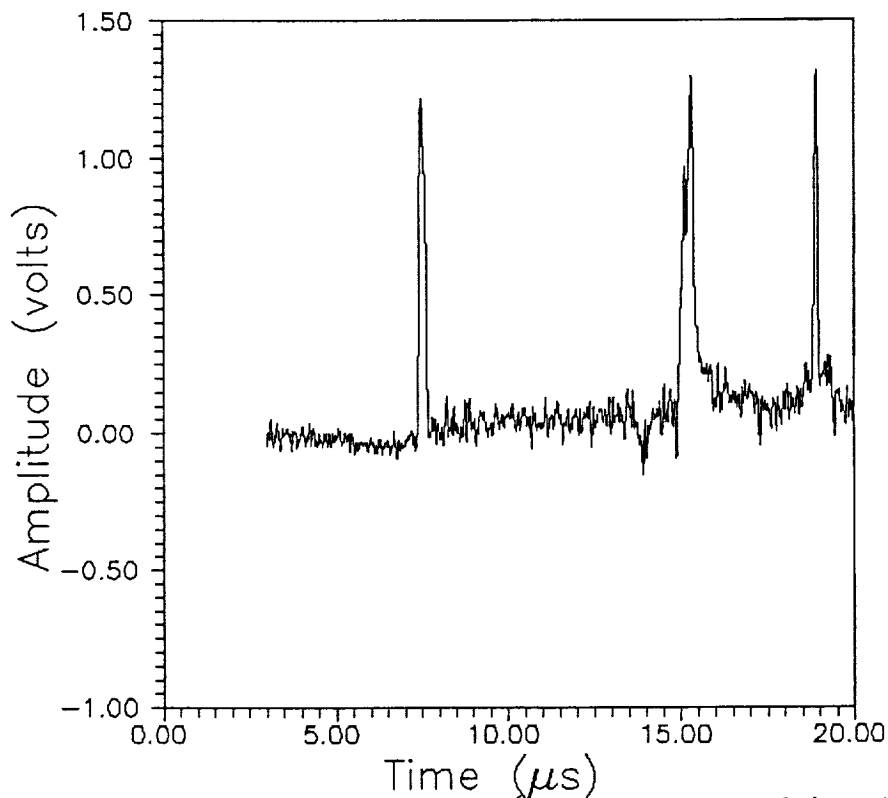




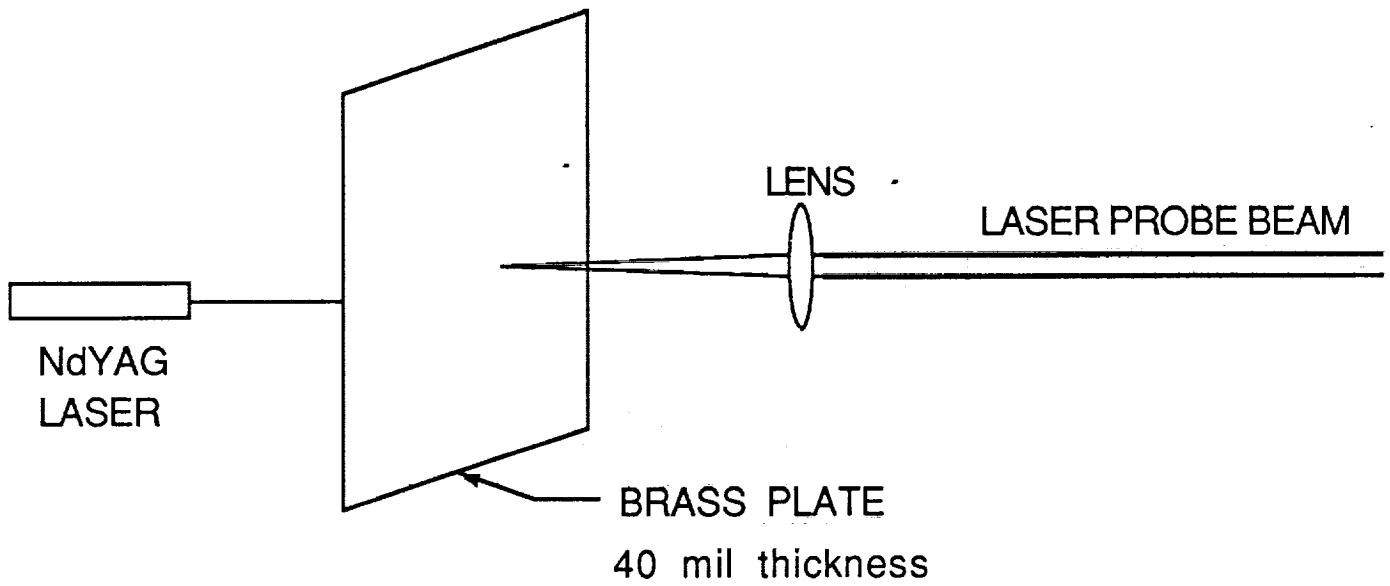
### Piezoelectric Detection



### Interferometric Detection

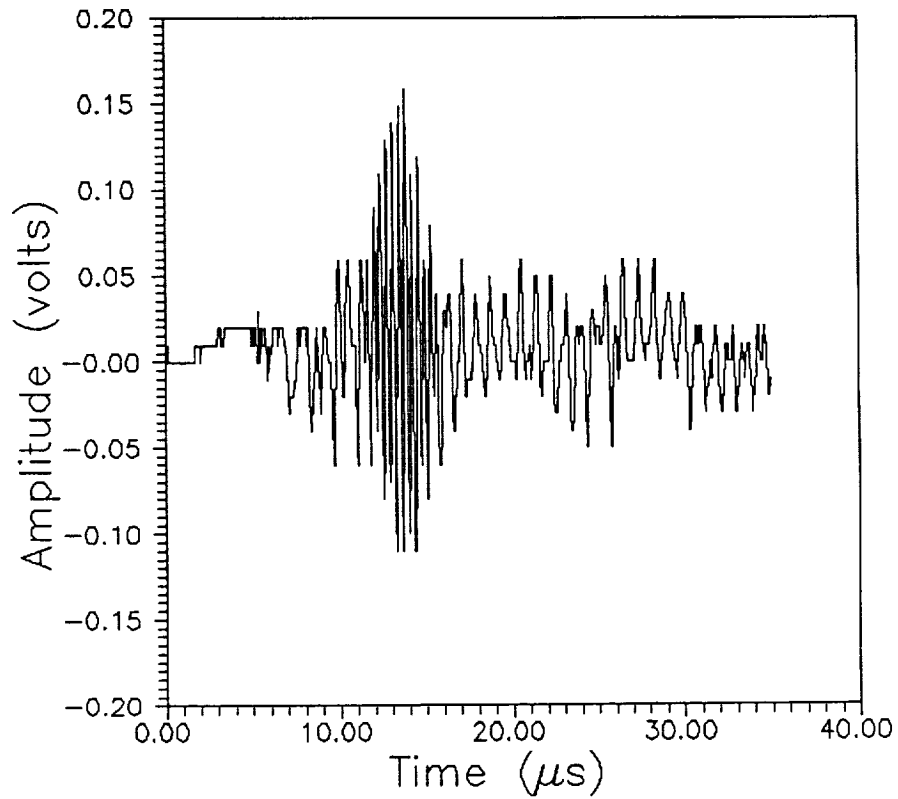


Laser Generated Ultrasound (Al Block-Off Epicenter)

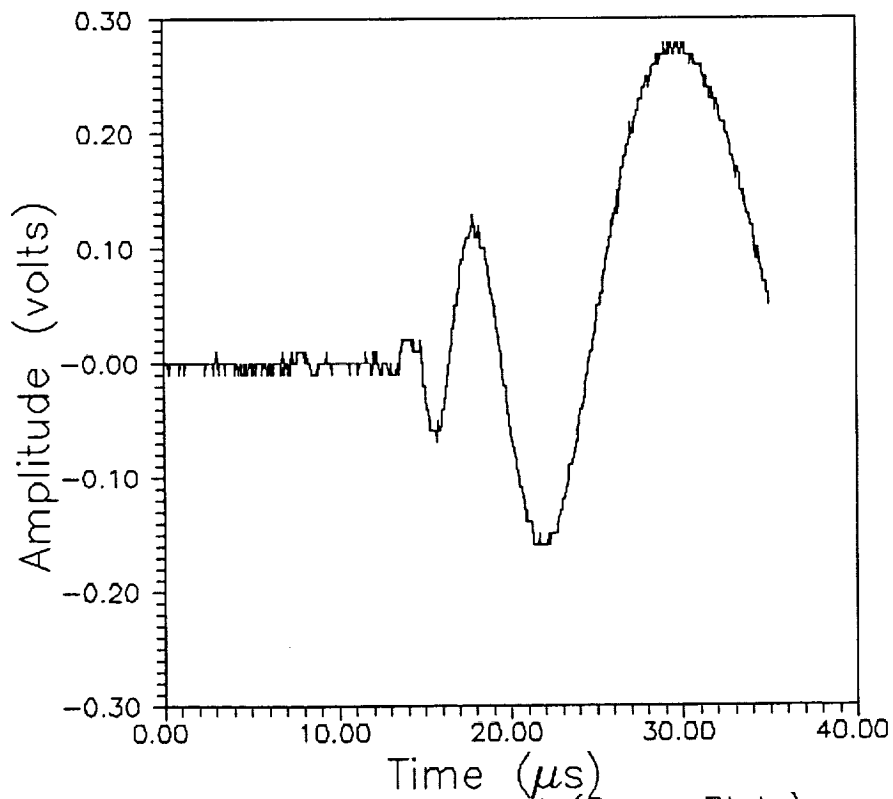


## NON-CONTACT GENERATION AND DETECTION OF ULTRASOUND IN A BRASS PLATE

### Piezoelectric Detection

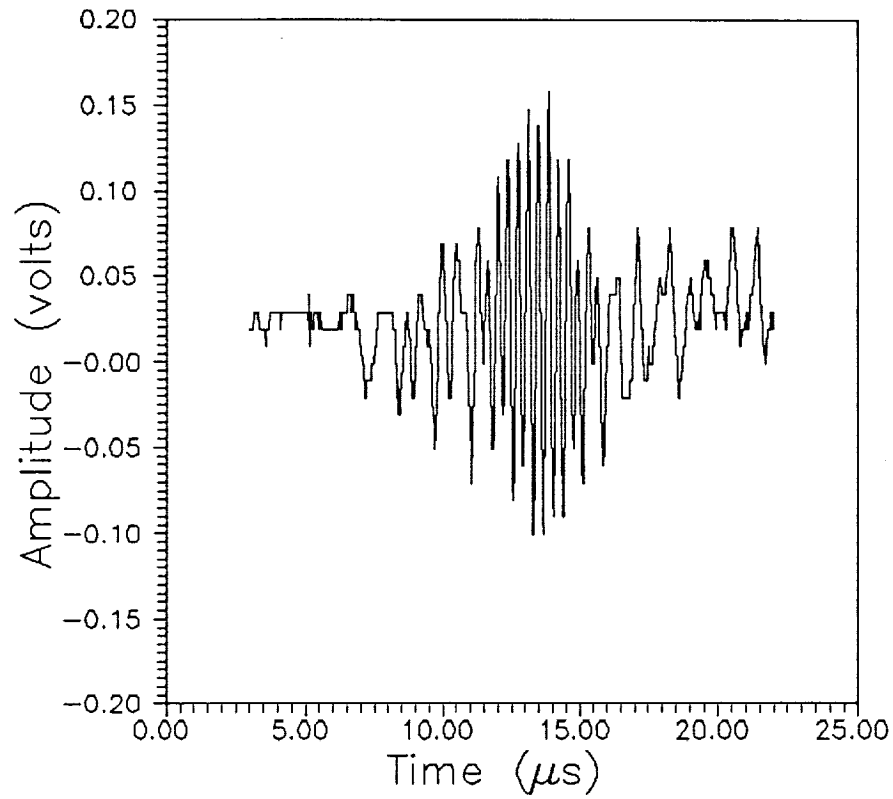


### Interferometric Detection

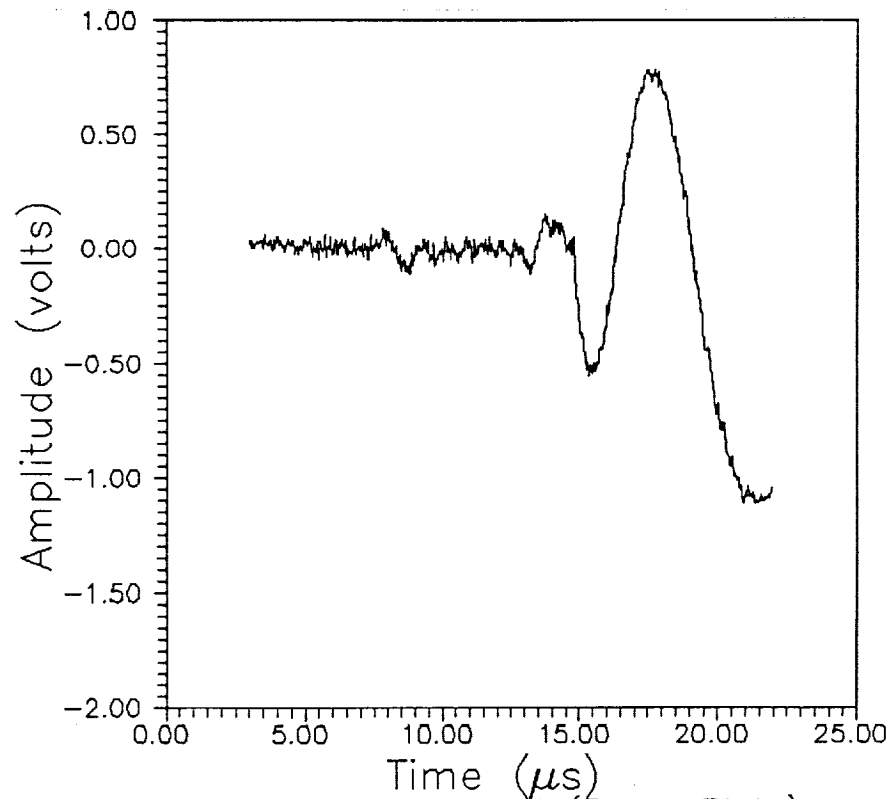


Laser Generated Ultrasound (Brass Plate)

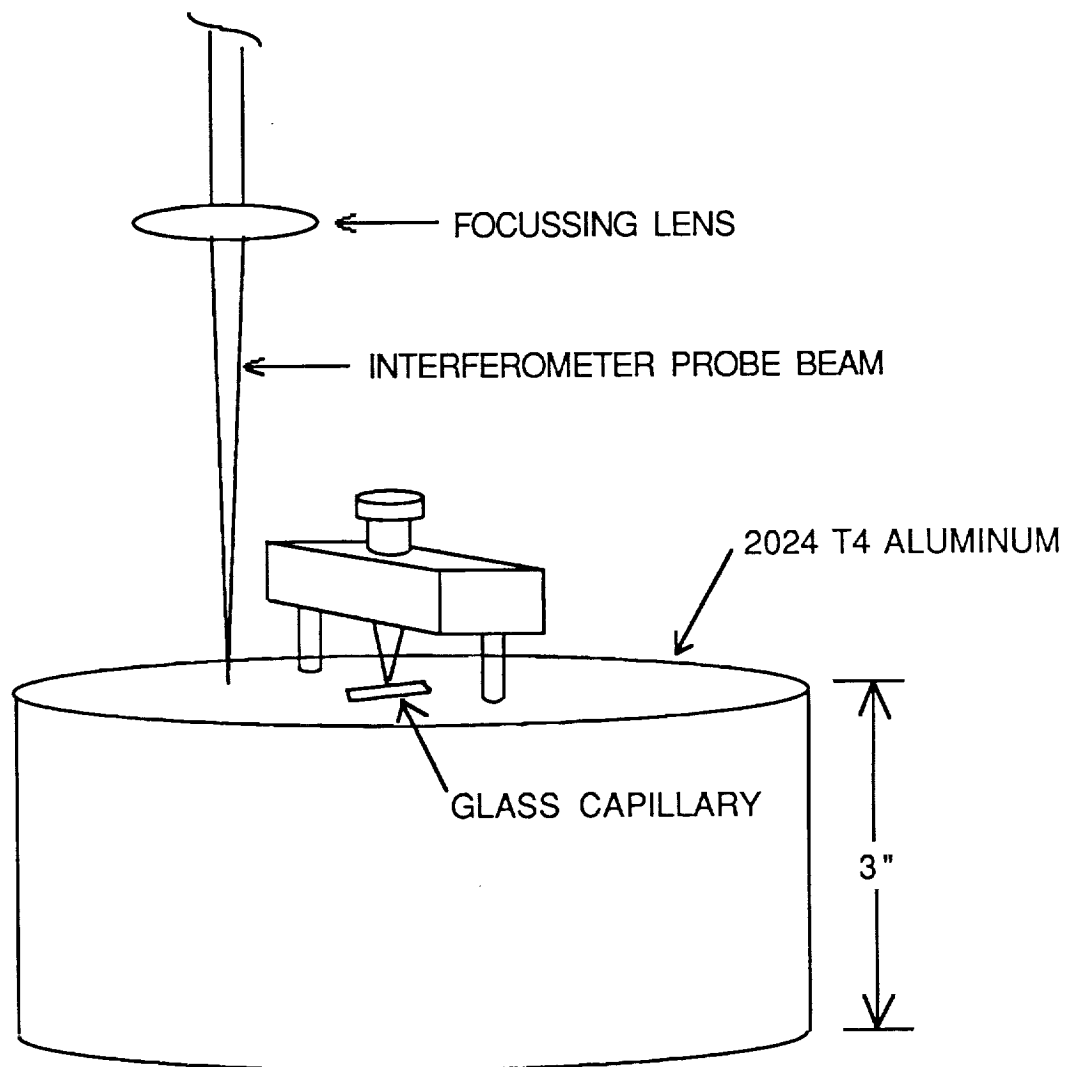
### Piezoelectric Detection



### Interferometric Detection



Laser Generated Ultrasound (Brass Plate)



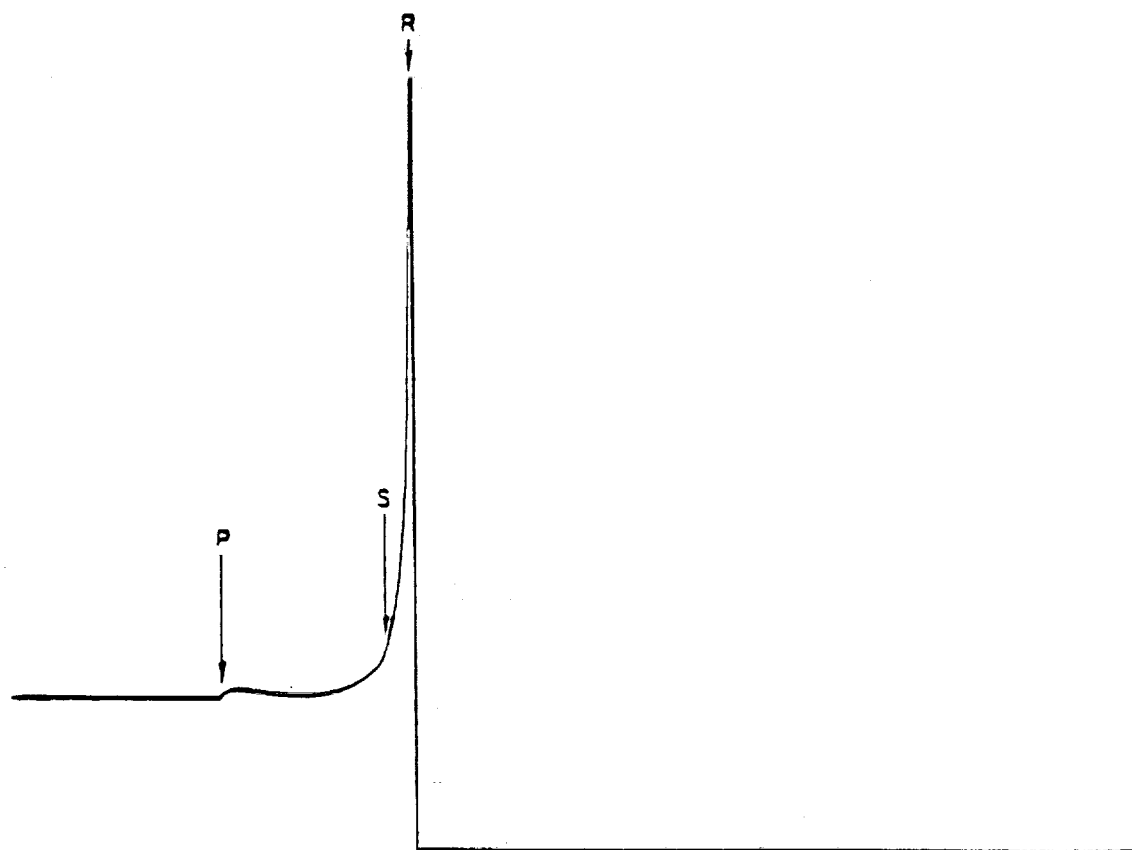
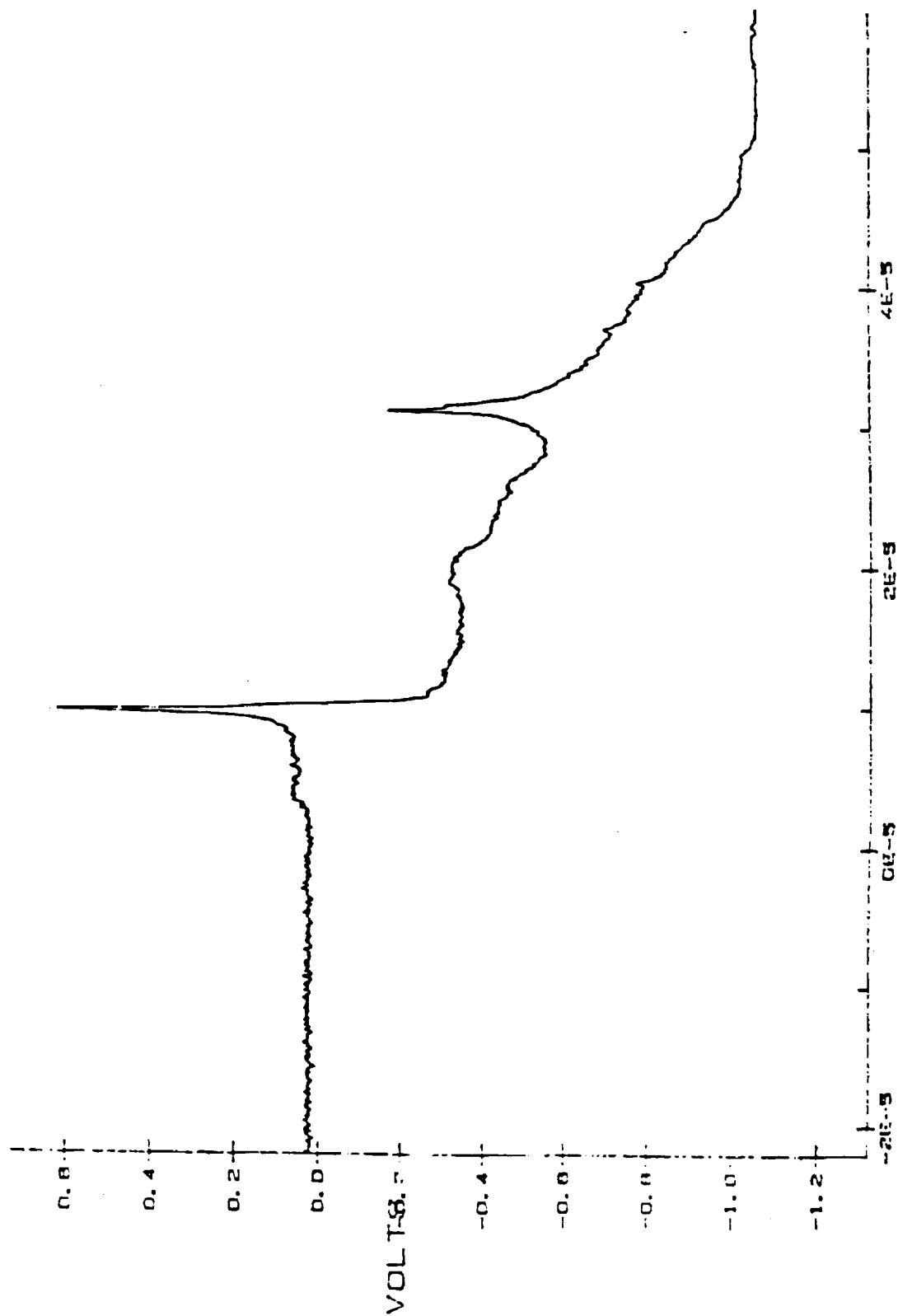
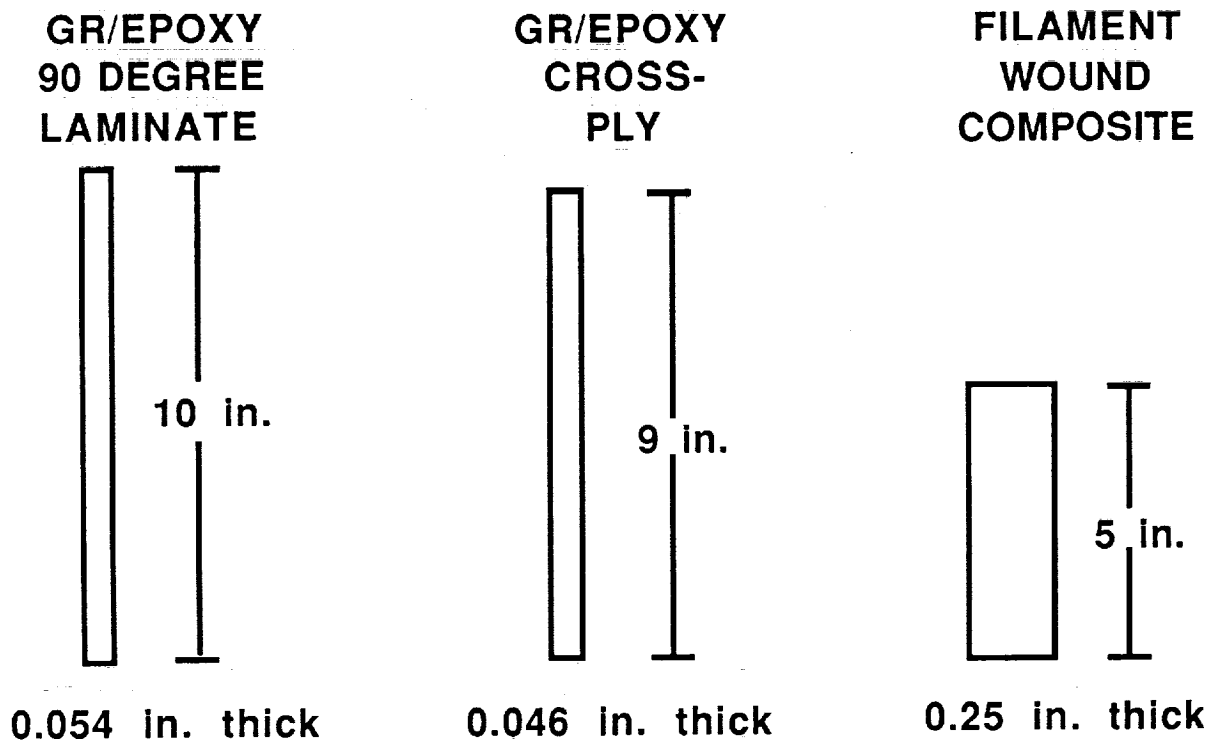


Figure 2. THEORETICAL RECORD OF A STEP-LOADING  
POINT SOURCE STRIKING AN INFINITE HALF-SPACE

FLTRXO



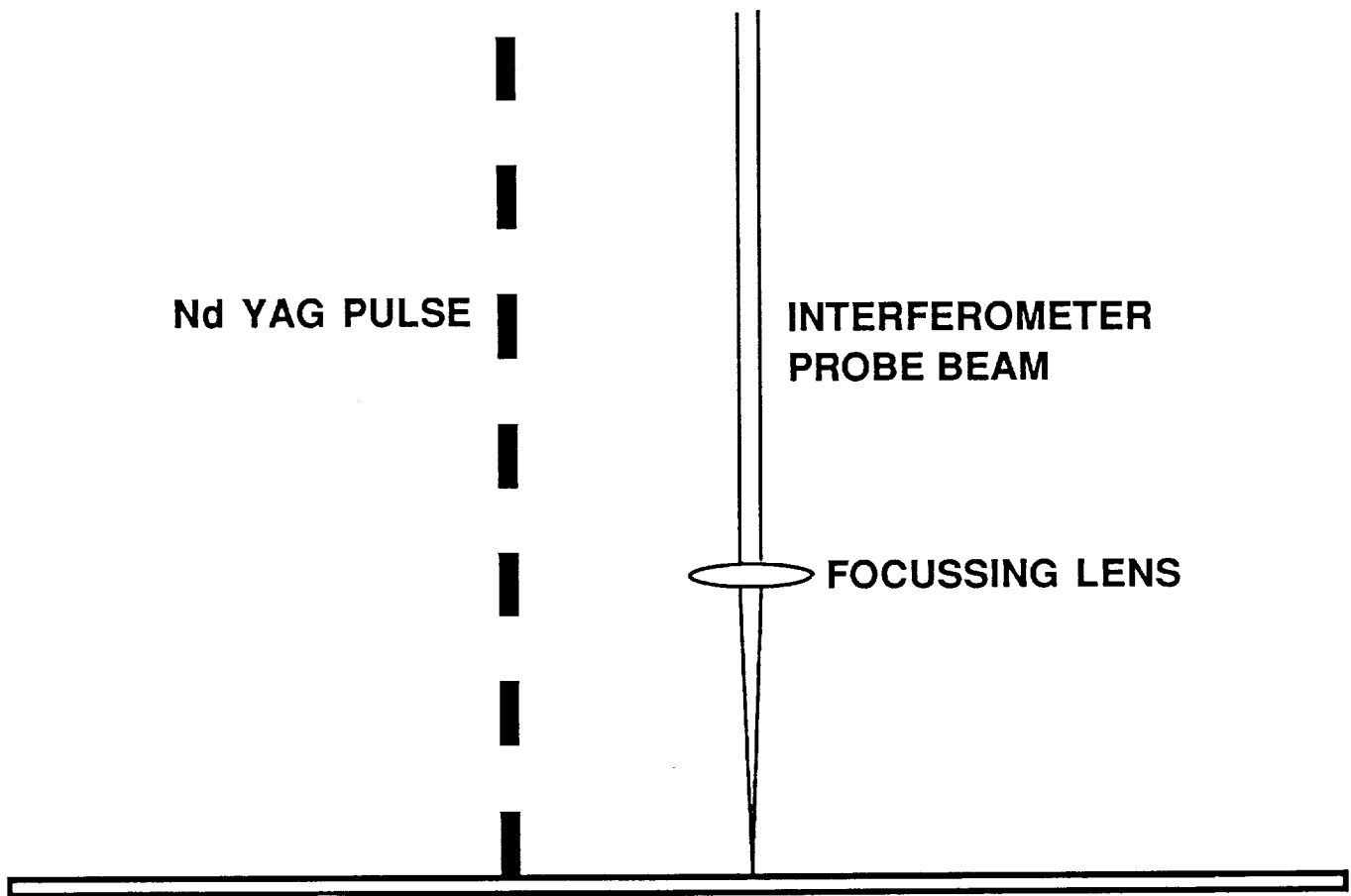
## DIMENSIONS OF SAMPLES USED IN LASER ACOUSTO-ULTRASONIC TESTS



(ALL SPECIMENS 0.5 INCHES WIDE)

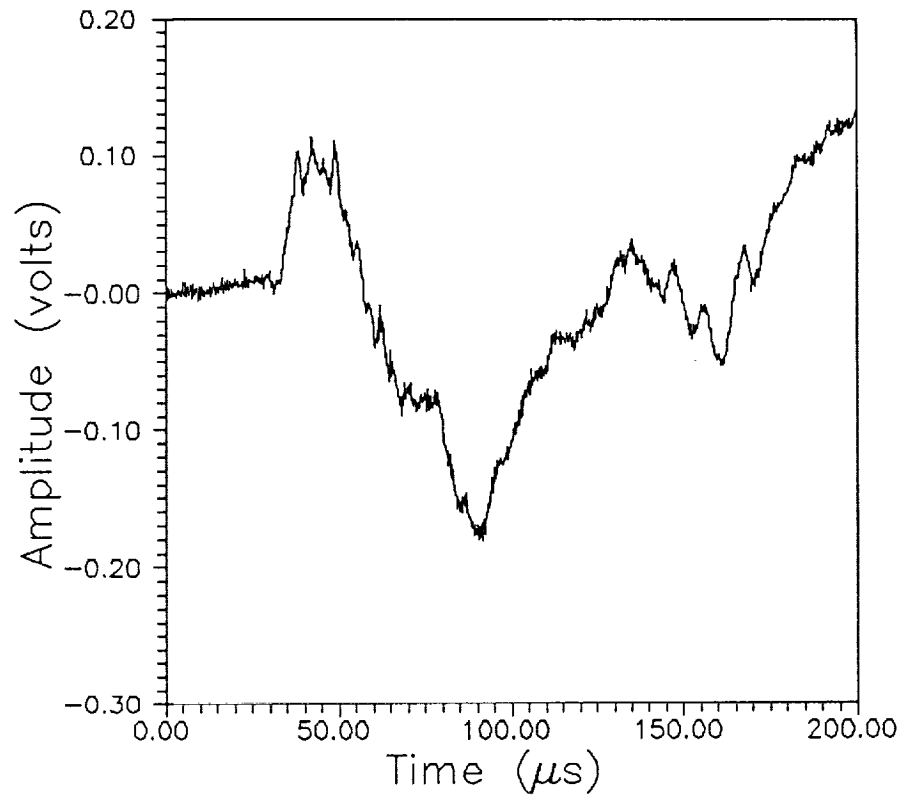
**\*3M SILVER POLYESTER FILM TAPE WAS USED AT  
DETECTION SITES TO INCREASE REFLECTIVITY**



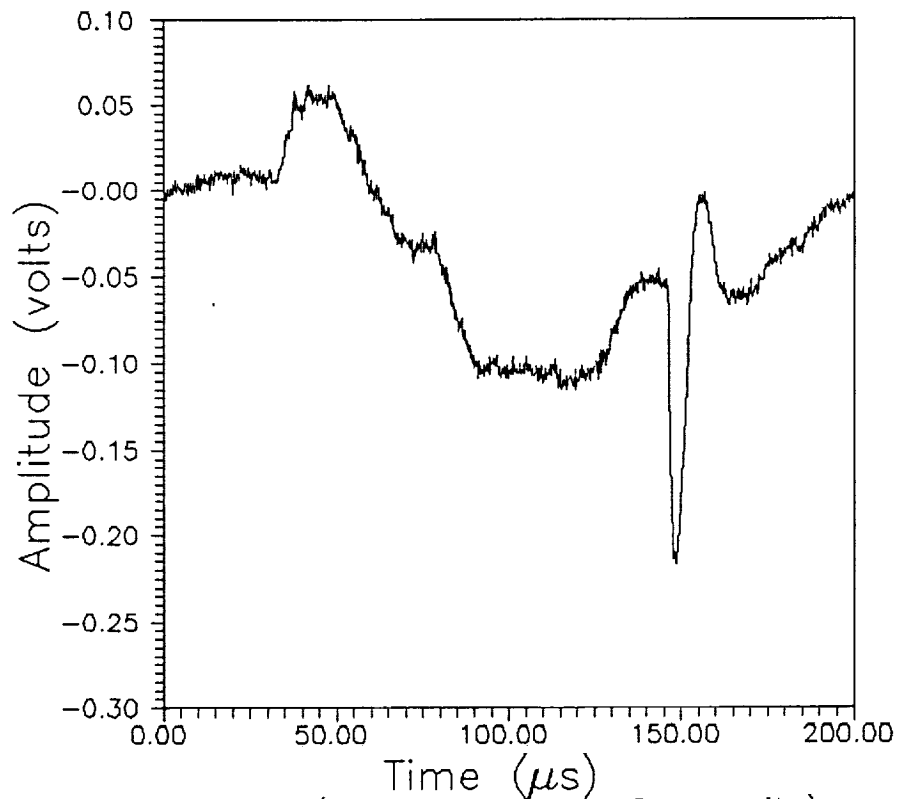


## **LASER ACOUSTO-ULTRASONICS**

### Piezoelectric Detection

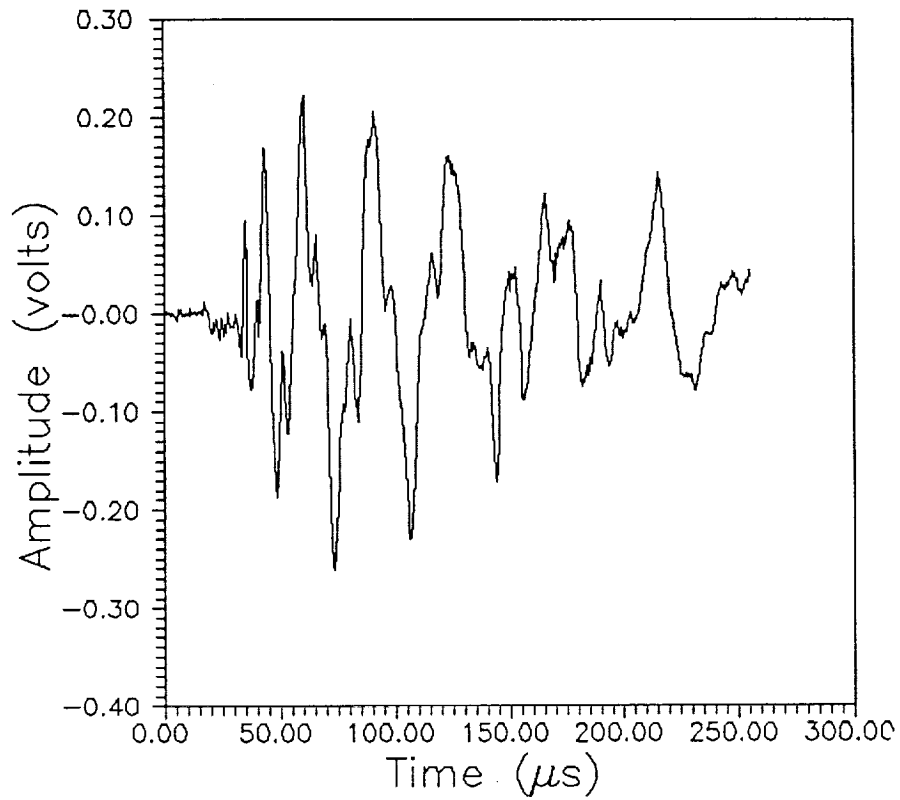


### Interferometric Detection

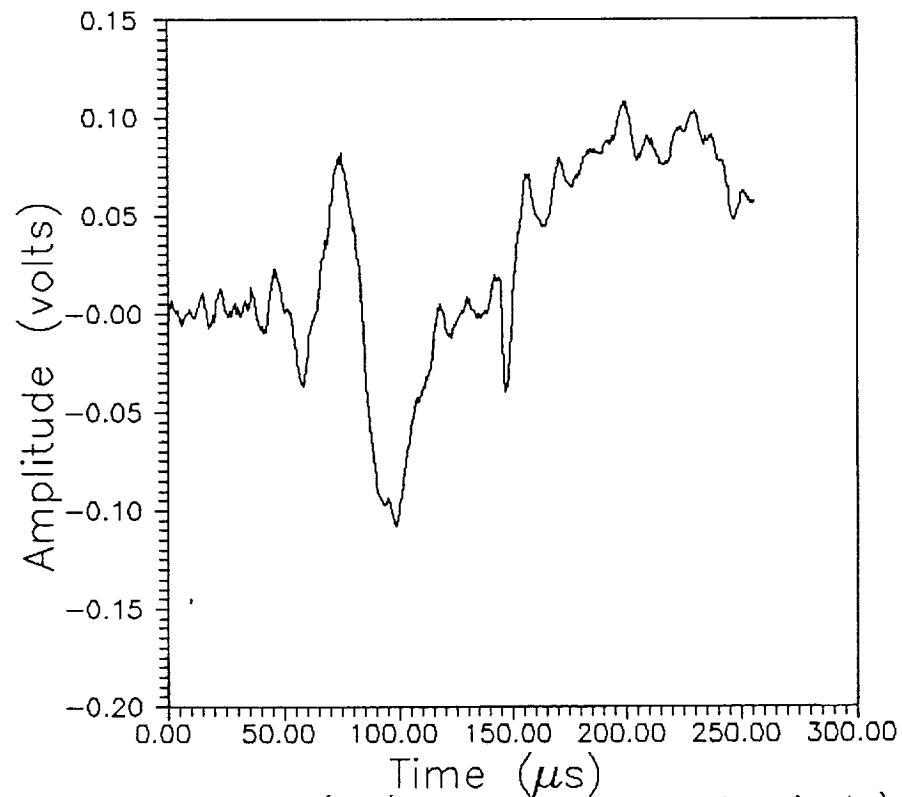


Laser Generation (Filament Wound Composite)

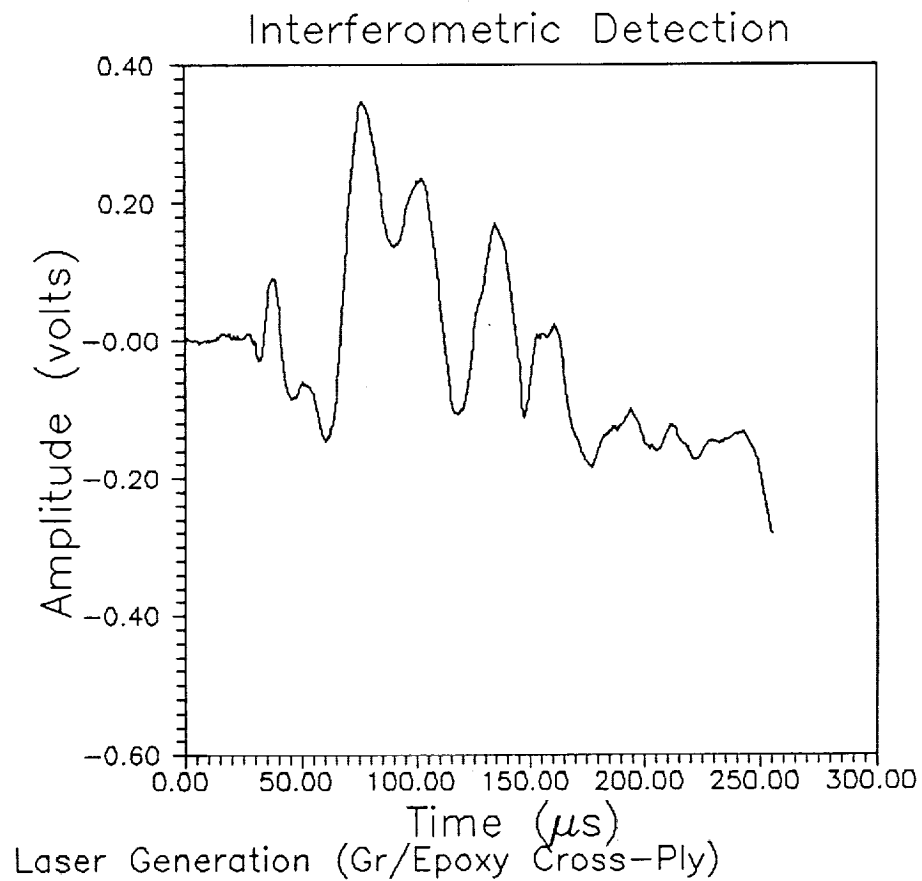
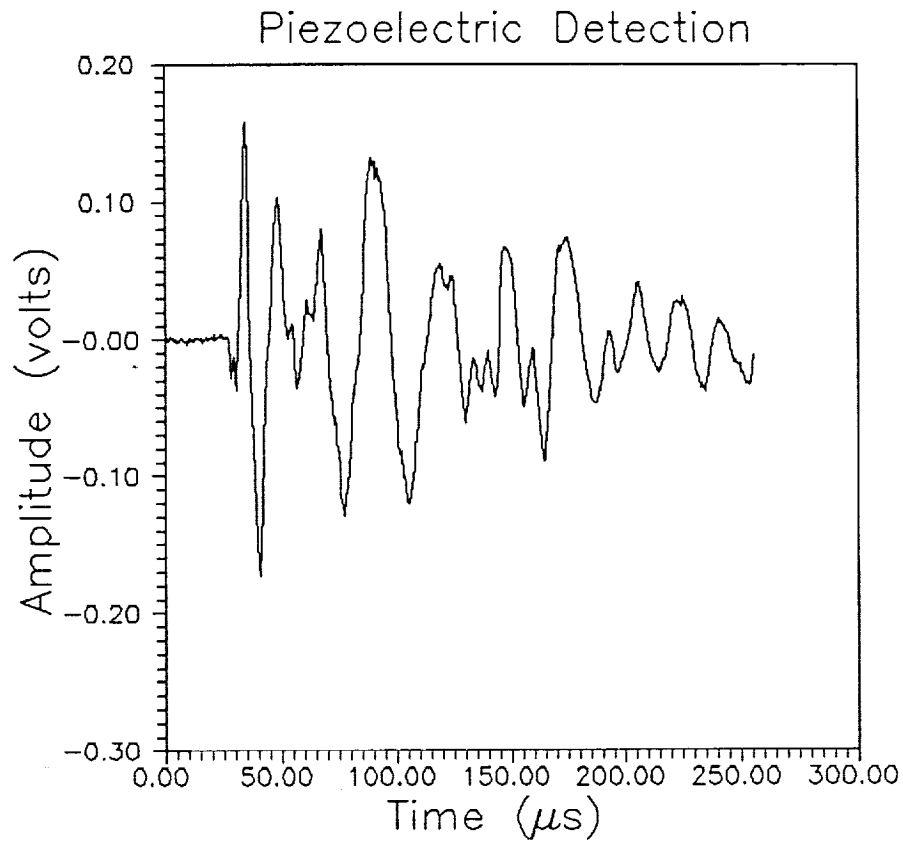
### Piezoelectric Detection



### Interferometric Detection

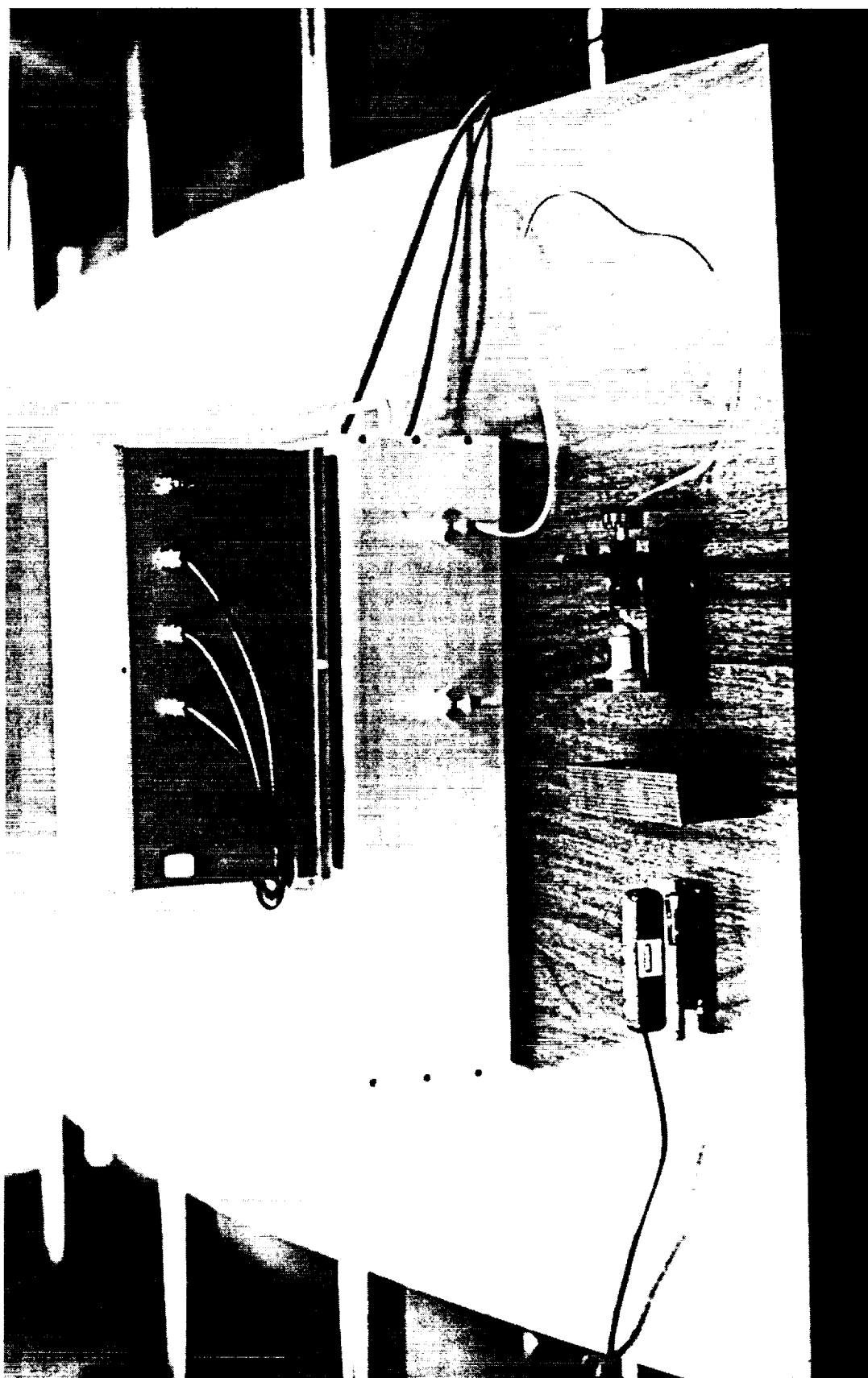


Laser Generation (Gr/Epoxy 90 Degree Laminate)



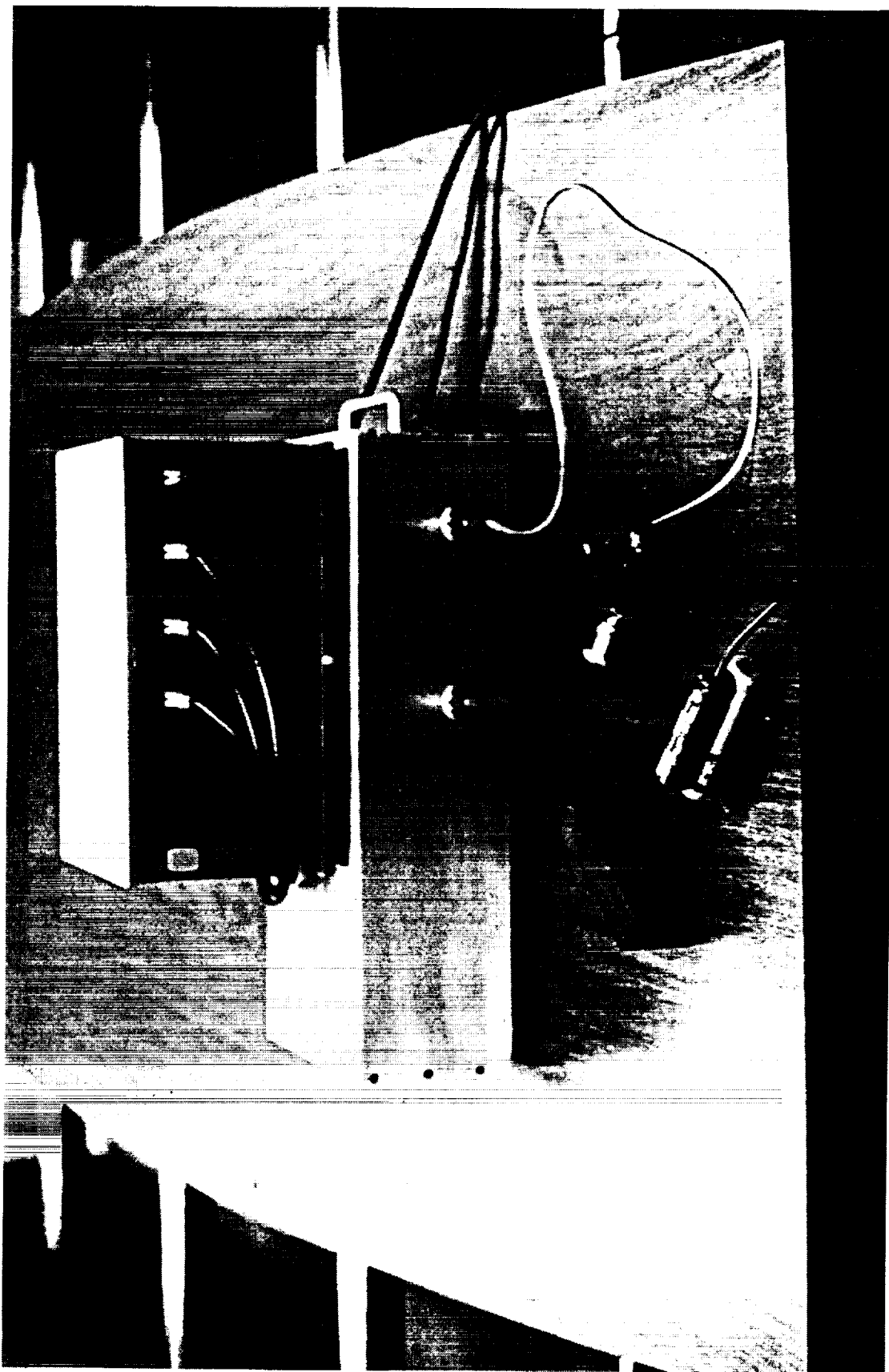
## **SUMMARY**

**LASER ACOUSTO-ULTRASONICS COMPLEMENTS  
STANDARD PIEZOELECTRIC ACOUSTO-ULTRASONICS  
AND OFFERS NON-CONTACT NONDESTRUCTIVE  
EVALUATION.**



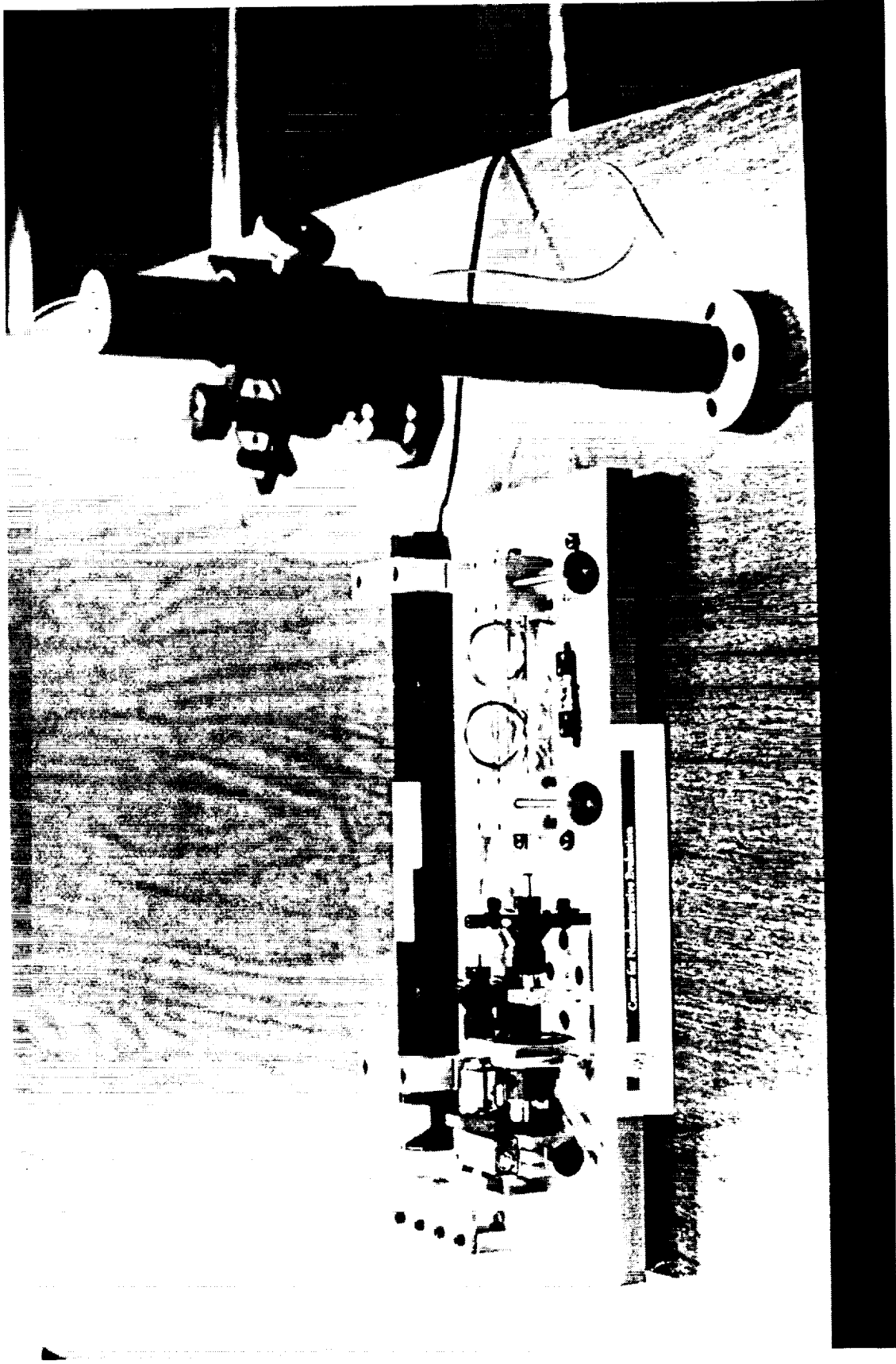
ORIGINAL PAGE  
BLACK AND WHITE PHOTOGRAPH

ORIGINAL PAGE IS  
OF POOR QUALITY



ORIGINAL PAGE  
BLACK AND WHITE PHOTOGRAPH

ORIGINAL PAGE IS  
OF POOR QUALITY



ORIGINAL PAGE  
BLACK AND WHITE PHOTOGRAPH

ORIGINAL PAGE IS  
OF POOR QUALITY